THE

DESCRIPTION AND USE

OF A

NEW PORTABLE

ORRERY;

SHEWING,

By a moſt ſimple Conſtruction, the Motions of the Earth and Moon, round the Sun, from whence the Nature and Cauſes of the viciſſitudes of the Seaſons, Days, and Nights, Solar and Lunar Eclipſes, &c. are clearly explained.

To which is prefixed,

A ſhort Account of the SOLAR SYSTEM, or the true SYSTEM of the WORLD.

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PREFACE.

THE Orrery deſcribed in the following ſmall Tract, is conſtructed upon the principle of one contrived (as I am informed) by the ingenious Mr. Ryland, of Northampton, about three Years ago, for the uſe of his Pupils.—But now in a more complete and uſeful State than that was, by the few Improvements that I have ſince added to it, and by its having only four Wheels, and two Pinions, to ſhew all the Phænomena it explains, recommends itſelf to the Public for Simplicity and Cheapneſs, particularly to Maſters and Governeſſes of Boarding Schools, Private Tutors, &c. For by putting ſuch an Inſtrument as this into the Hands of their Pupils, they will acquire more knowledge of the moſt uſeful and intereſting part of Aſtronomy in one Day than by the ſtudy of Books in one Year.

Among the Purchaſers of the Orrery I flatter myſelf the Fair Sex will bear no ſmall part, ſuch an Inſtrument as this having been for ſome time wanted for them, as the large and complete Orreries are ſcarce, and only to be met, with in the Hands of the Curious and the Wealthy.

My reaſon for prefixing a ſhort Account of the Solar Syſtem, is obvious, it is to prevent the unlearned Tyro the trouble and expence of turning to Volumes, on Aſtronomy, to be informed of that only which Orreries (with conveniency) cannot proportionally repreſent, viz. the Diameters and Diſtances of the Primary and Secondary Planets there repreſented.

I hope I ſhall be excuſed by the Learned, for having interſperſed in the courſe of this little Compilation a few borrowed Sentiments, which poſſibly may be the means of exciting ſome Perſons to an enquiry into the ſublime Science of Aſtronomy, and thereby render themſelves converſible among the ſenſible part of Society, and prevent their being miſled by the Aſſertions of the ignorant.

To conclude, the Candor and Forgiveneſs of the Reader is here intreated, for any Errors or Imperfections he poſſibly may diſcover in the following Pages, as they are the production of a Youth's firſt Attempt, to explain to the unlearned in Aſtronomy, the Cauſes of the moſt conſpicuous and intereſting Phænomena of the Heavenly Bodies.

THE
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PART I.

A ſhort Account of the Solar Syſtem.

1. IT has been indiſputably proved by ſeveral eminent Aſtronomers, and is now univerſally allowed by the generality of Perſons, that the Earth is a Planet, and with its Attendant the Moon, revolves round the Sun, as a central body, by the ſame cauſe as the other revolving Planets, Mercury, Venus, Mars, Jupiter, and Saturn, viz. an attractive power in the Sun, con-

joined with a projectile force, or a motion perpendicular to the Sun's attractive or central power; alſo, that the paths (called Orbits) which they deſcribe are not circular, but rather elliptical, and more, or leſs ſo, according to the adjuſtment of the above two powers.

2. As that ſyſtem of the heavenly bodies which has the Sun for its center is called the Solar Syſtem, I ſhall immediately proceed to give a ſummary deſcription of the ſeveral bodies that compoſe it, and ſuch particulars of each as are the moſt remarkable, annexing at the ſame time a conciſe deſcription of the fixed Stars from the accounts of modern Aſtronomers, who to their honor and credit be it ſaid, have ſpared no expence or pains to render the knowledge of the conſtituent parts of the univerſe familiar and eaſy.

3. The Solar Syſtem, or the Syſtem of the Planets I am now going to deſcribe, is, of all the different ſyſtems that have been invented, the moſt ancient, and the moſt rational to an unprejudiced conſiderer, for we are informed that it was invented and taught by the famous Greek Philoſopher, Pythagoras, who flouriſhed about 500 years before Chriſt; and by ſeveral of his followers; but being loſt in the prejudices of ſenſe and opinion, until about 300 years ago, when it was again renewed and ſupported by the famous Poliſh Philoſopher, Nicholas Copernicus, who was a Native of Thorn. In this he was followed and confirmed by the moſt renowned Mathematicians and Philoſophers that have ever flouriſhed, as Kepler, Galileo, Deſcartes, Gaſſendus, and the incomparable Sir Iſaac Newton, who has eſtabliſhed this ſyſtem on ſuch a permament baſis of truth and demonſtration, as to reſiſt all the efforts of ignorance

and error, and from the above philoſophers it has received the various names of the Pythagorean, Copernican, and Newtonian ſyſtem, but now the Solar or true Syſtem of the World.

4. There were two ſyſtems generally believed at the time of the obſcurity of the Solar Syſtem, one by Ptolemy, an Egyptian Aſtronomer, ſuppoſed to live 138 years before Chriſt. The other by a noble Dane, named Tycho Brahe, born in Schonen, A. D. 1546.

5. The Ptolomaic Syſtem, ſuppoſed the Earth to be immoveably fixed in the center of the univerſe, and about which moved the ſeven Planets, viz. the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn, beyond theſe the firmament of ſtars, then two chryſtalline ſpheres, all of which received motion from the Primum Mobile, or firſt mover, which revolved about the Earth in 24 hours from eaſt to weſt. But as this ſcheme was only agreeable to appearances, and incapable of ſtanding the teſt of art and obſervation, it was rejected as a combination of errors and abſurdities.

6. The Tychonic Syſtem, was invented after the Ptolomaic but was never ſo general; this ſuppoſed the Earth to be the center of the firmament of ſtars, as alſo the two luminaries the Moon and the Sun, but it ſuppoſed the Sun to be the center of the planetary motions, viz. of Mercury, Venus, Mars, Jupiter, and Saturn; theſe with the Sun revolved about the Earth to account for the annual or yearly motion, and the Earth revolved about its axis every 24 hours from weſt to eaſt, to account for the apparent diurnal or daily motion of the heavenly bodies from eaſt to weſt. This hypotheſis being in part true and in part falſe was embraced by few, and ſoon ſurrendered to the

only rational or true ſyſtem reſtored by Copernicus, and demonſtrated by Sir Iſaac Newton, viz.

The Solar Syſtem,

Which has the Sun for its center, and the Planets with their Satellites or Moons, and Comets, revolving round him in the following order, beginning firſt with

7. The Sun, an immenſe globe of fire from which all the planets receive their light and heat, computed to be above 800,000 Miles in diameter and if ſo his bulk muſt be a million times greater than our Earth.

8. Mercury, the firſt planet in the ſyſtem, at the diſtance of 32 million of miles, revolves about the Sun in 87 days and 23 hours. Its diameter is computed to be 2600 miles, and its light and heat ſeven times greater than ours.

9. Venus, the ſecond planet, which at the computed diſtance of 59 millions of miles, revolves about the Sun in about 224 days 17 hours. Her diameter is 7906 miles, and light and heat twice as great as ours, and is the moſt brilliant planet of any in the Heavens, frequently ſhewing herſelf in the day time.

10. The Earth, or that Planet on which we live, is the third planet in order from the Sun, and is at the diſtance of 90 millions of miles from it; its revolution about the Sun is in 365 days, and 6 hours, moving at the rate of 58000 miles every hour. This motion cauſes the Sun to appear to move round, in the Heavens in that time; alſo it has another motion round an imaginary line, called its axis, every 24 hours, from weſt to eaſt,

which cauſes an apparent diurnal motion of the Heavens from eaſt to weſt; by this ſwift motion of the Earth on its axis, the inhabitants of London are carried 580 miles every hour, beſides the 58000 miles by the yearly motion above mentioned. The Earth is 7960 miles in diameter, and is the firſt planet in the ſyſtem that is attended by a Moon, or Satellite.

11. The Moon, an attendant of the Earth's, revolves about the Earth from change to change, in 29 days and 12 hours, at the diſtance of about 240,000 miles, and is about 2175 miles in diameter, and therefore about 50 times leſs than the Earth. From the motions of the Earth and Moon round the Sun, and from the various ſituations of the Sun, Earth, and Moon, in reſpect to each other, ariſe the viciſſitudes of the Seaſons, Days, and Nights, Eclipſes, &c. which, and their cauſes the Orrery hereafter to be deſcribed, will evidently repreſent.

12. Mars, the fourth planet from the Sun, at the diſtance of 123 millions of miles, circulates about the Sun in 687 days, being 4444 miles in diameter, and always having a red or fiery aſpect.

13. Jupiter, the fifth planet, is the largeſt of all the planets, being no leſs than 81000 miles in diameter, and therefore a thouſand times bigger than the Earth, revolves about the Sun in about 12 years, at the diſtance of 424 millions of miles; and is attended with four Moons ſimilar to that of the Earth's, their diſtances and periods being as follow; the firſt Moon at the diſtance of 229,000 miles from his center, goes round him in one day 18 hours and 36 minutes; the ſecond, at 364,000 miles, in 3 days 13 hours and 13 minutes; the third, at 580,000 miles, in 7 days 3 hours and 59

minutes; and the fourth, or laſt, at 1000000 of miles, in 16 days, 18 hours, and 30 minutes.

14. Saturn, the moſt diſtant of the ſyſtem, being about 780 millions of miles from the Sun, and revolves about him in nearly 30 years; its diameter is about 68,000 miles, and it is encircled with a very large ring, at the diſtance of 20,000 miles, which is alſo the breadth of the ring; it is attended by 5 Moons, the diſtances and periods of which are as follow; the firſt, at the diſtance of 140,000 miles, goes round him in one day 21 hours and 19 minutes; the ſecond, at 187,000 miles, in 2 days 17 hours and 25 minutes; the third, at 263,000 miles, in 4 days 12 hours and 25 minutes; the fourth, at 600,000 miles, in 15 days, 22 hours, and 41 minutes; and the fifth, or laſt, at 1 million, 800,000 miles, in 79 days, 7 hours and 40 minutes.

15. There are another kind of planets moving round the Sun, beſides what have been juſt deſcribed, called Comets, which are ſuppoſed to be ſolid opaque bodies, with long fiery tranſparent tails, iſſuing from that ſide which is oppoſite to the Sun, and to move in very excentric or oval orbits, and are amazingly heated by their near approaching to the Sun, for according to Sir Iſaac Newton, the Comet that appeared in 1680, when neareſt to the Sun, was 2000 times hotter than a red hot iron, and retains its heat until its return again, which is in 575 years. This Comet at its greateſt diſtance from the Sun was computed to be 11000 and 200 millions of miles diſtant, and at its neareſt diſtance 490,000 miles, moving in its orbit with

the velocity of 800,000 miles every hour,* The number of Comets belonging to our ſyſtem, is uncertain, as they ſo ſeldom fall under the obſervation of Aſtronomers, having ſuch very long periods, and attended by ſuch different appearances, but by the beſt accounts we are informed there is about 21, and that the periods of three only are known.

Having now got to the limits of our ſyſtem we ſhall proceed to the Orrery, after giving an explication of thoſe bodies in the Heavens, which have no connection with our planetary ſyſtem, (as many do ſuppoſe) but appear fixed, from whence they are called

16, The Fixed Stars, which are thoſe luminaries above our heads that in the abſence of our Sun conſtitute the ſpangled canopy of the Heavens; and are ſuppoſed by modern Aſtronomers to be Suns, made for the ſame purpoſes as our Sun, each to beſtow light, heat, and vegetation, on a certain number of inhabited planets, kept by gravitation within the ſphere of its activity.

17. The number of the Stars, including thoſe that cannot be ſeen without the teleſcope, is infinite; but thoſe that are viſible by our naked eyes, limited; for, in a clear winter's night, without moonſhine, there is not to be diſcerned above 1000, as any perſon may convince himſelf by applying to a good Cœleſtial Globe, where he will

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* See Ferguſon's Aſtronomy, or Martin's Young Gentleman's and Lady's Philoſophy, in 3 Vols, Octavo: two excellent Treatiſes for eaſily introducing Learners to a knowledge of the Heavens, either of which, or any other Philoſophical Publication may be had of me, at my Father's, as directed in the Title-page.

ſee all the Stars, divided into parcels or conſtellations, having particular names to each, by which they may eaſily be diſtinguiſhed in the Heavens. The white path ſeen among the Stars, is called theGalaxy, or milky way, and is ſuppoſed to be an innumerable quantity of Stars, which by their combined luſtre cauſe the white appearance that it is attended with. The diſtance of the Stars from the Earth, and alſo from each other, is ſuppoſed to be immenſurably great, for one of the largeſt and moſt brilliant Star in the Heavens, thought to be the neareſt of any to us, called Sirius, is calculated to be at no leſs a diſtance than 2,200000,000000 viz. 2 billions and 2 hundred thouſand millions of miles, and that a cannon ball diſcharged from the Earth with the velocity of 480 miles an hour, would not arrive at it in leſs time than 700,000 years. Thoſe Stars that appear the largeſt, and have the greateſt luſtre, are called Stars of the firſt magnitude; the next in luſtre, Stars of the ſecond magnitude; and ſo on to Stars of the ſixth magnitude, which are the ſmalleſt that can be diſcerned by the bare eyes in a clear ſtar-light night. The vehement twinkling of the Stars is occaſioned by the tremulous motion of particles in the Air, for the Stars appearing like points, will by every intervening opaque particle in the Air be eclipſed every now and then, ſo as to cauſe a twinkling or ſcintillation, but the planets appearing larger can ſuffer no ſuch occultation, hence, here is a certain method of diſtinguiſhing the Planets from the Stars: the apparent daily motion of the Stars from eaſt to weſt, ariſes from the real motion of the Earth on its axis, and the different ſets of Stars that we ſee at different times of the year, from the annual motion of the Earth in its orbit (ſee § 10) which with the daily motion will be clearly ſhewn in the Orrery. There are ſeveral other curious particulars of the Stars which this ſmall treatiſe will not admit me to enlarge upon, but are fully explained by the Authors before mentioned in note to § 15.

18. It may not be improper to inſert here an account of a very frequent Meteor called a Falling Star, which by many perſons ignorant of the nature of the ſtars, is thought to be really as its name imports, but to remove their prejudices, they are to underſtand, that it is a fiery Meteor kindled in the Air by the mixture of inflammable ſubſtances, and then having the appearance of a Star, and as all ſuch bodies move very rapidly like a ſky rocket, while they diſſipate themſelves, ſo theſe Meteors have the appearance of ſhooting or falling Stars, until they become extinguiſhed.

19. Upon a reflection on the nature and properties of the fixed Stars here communicated to us, what an amazing, exquiſitely grand, and ſublime idea does it afford us, of the ſtructure of the univerſe, not compoſed of one Sun, and one World, as the ignorant in Aſtronomy conceive, but conſiſting of ſuch an inconceivable number of Suns, Syſtems, and Worlds, diſperſed through the infinite abyſs of ſpace, that if our Sun, with all the Planets, Moons, and Comets, appertaining thereto were annihilated they would be no more miſſed by a perſon that could ſurvey the whole Creation, than a grain of ſand from the ſea-ſhore, the ſpace they occupy being comparatively ſo minute, that it would ſcarce be a ſenſible blank in the univerſe, notwithſtanding Saturn, the moſt diſtant of all the Planets, revolves about the Sun in an orbit of 4,884 millions of miles in circumference, and

ſome of our Comets make excurſions upwards of 10,000 millions of miles beyond Saturn's orbit, and yet at that amazing diſtance they are incomparably nearer to the Sun than any of the Stars, and returning periodically by the efficacy of the Sun's attraction.

20. And do not thouſands of thouſands of Suns, multiplied without end, and ranged all around us, at immenſe diſtances from each other* attended by ten thouſand times ten thouſand Worlds, all in rapid motion, yet calm, regular, and harmonious, invariably performing the paths preſcribed them: Worlds, peopled with Myriads of intelligent beings, formed for endleſs progreſſion in perfection, and felicity; Does not this I ſay evidently convince us of the exiſtence of a deity? the ſuperlative greatneſs, the infinite wiſdom, and the paternal goodneſs of whom is moſt gloriouſly diſplayed in this ſtupendous fabric of the univerſe.

21. What an abundance of delight, and rational pleaſure then, is to be obtained by the ſtudy and contemplation of the works of the Creator? and how much approbation and encouragement do thoſe contrivances deſerve, the deſign of which is to facilitate ſuch uſeful knowledge to the underſtandings of the youth of both ſexes? making them both wiſe and happy, not vainly ſpending their precious and irrevocable time in the idle and prophane amuſe-

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* So great are the diſtances of ſome of the Stars ſuppoſed to be at, that Mr. Huygens, an ancient Aſtronomer, ſuppoſed that the light of many of them had not yet reached the Earth ſince its creation.

ments of the age, but enjoying it by reſearches into the unbounded field of nature, which will unavoidably lead them to confeſs with the pſalmiſt that "'tis "God who hath laid the foundation of the Earth, "and that the Heavens are the work of his hands".

22. Having now finiſhed the ſhort account of the Solar Syſtem deſigned to convey ideas of that part of Aſtronomy which Orreries (with conveniency) cannot proportionally repreſent, viz. the proportional diſtances and diameters of the primary and ſecondary Planets, we muſt begin with the deſcription of the Orrery, which will to any perſon beſtowing the leaſt attention on it greatly familiarize thoſe phænomena of the univerſe it is intended to repreſent.

End of Part the Firſt.

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OF A

NEW PORTABLE

ORRERY,

On a moſt Simple Conſtruction, &c.

PART II.

1. TO any perſon ever ſo little acquainted with the ſcience of Aſtronomy, the ſtructure of the Orrery, and its uſes are evident by only a bare inſpection; but for the benefit of thoſe totally unacquainted with the ſcience, it will be neceſſary to give as intelligible a deſcription as poſſible, previouſly deſiring the learner to pay no reſpect to the diſtances and diameters of the Sun, Earth, and Moon, there repreſented, but for information in that point (ſee § 7 to § 14, Part I.

2. The board on which the frame of wheels, &c. turns, has a printed paper paſted and varniſhed on it, near the outward edge of which are ſeveral circles. The firſt, or outward circle is divided into twelve parts, containing the names of the twelve months of the year, and the next circle into their reſpective days; the two inmoſt circles have the twelve ſigns of the Ecliptic, each ſign containg 30 degrees, or the whole Ecliptic 360 Degrees: this Ecliptic circle repreſents that path in in the Heavens that the Sun ſeems to deſcribe in a year, it being properly the path of the Earth, round the Sun: ſee § 10, Part I.

3. The braſs Ball fixed in the center of the board, repreſents the Sun in the center of the univerſe.

4. The Ivory Ball, with ſeveral circles cut on it, denotes the Earth, and the braſs pin that it is ſupported on the Axis of the Earth; this braſs pin has an inclination to the board on which it goes round, thereby giving the Earth its proper poſition, called by Aſtronomers, the Inclination of the Earth's Axis, to the plane of the Ecliptic. This poſition never varies, and is therefore termed the Earth's paralleliſm to itſelf: It is this invariable poſition of the Earth, that cauſes the viciſſitudes of the Seaſons, and the different length of days and nights.

5. The top of the pin on which the Earth turns is called the North Pole, the bottom the South Pole; the two circles near theſe two Poles are termed Polar Circles, the upper one the North Polar Circle, and the under one the South Polar Circle; the two circles next to theſe are called the Tropics, the upper, the Tropic of Cancer, the under, the Tropic of Capricorn; the circle in the

middle

middle between the Poles is called, the Equator, becauſe it equally divides the Earth, for when the Sun is over that part of the Earth, it is equal Day and Night all over the Globe. There is another circle, which croſſes the Equator, and touches the Tropics in two points; this circle repreſents the path over the Earth that the Sun makes in a year, and is called the Ecliptic.

6. There are twenty-four other circles, called Meridian Circles, all meeting at the Poles, and croſſing thoſe juſt mentioned, theſe anſwer to the twenty-four hours of the day, in which time the Earth turns once round its Axis, making one day and one night, as will be ſhewn hereafter.

7. There is a ſmall piece of braſs put on the Earth, nearly between the upper Tropic and Polar Circle, which repreſents the place of London on the Earth, by which the various changes that this metropolis undergoes is more clearly ſhewn.

8. The ſemicircular braſs wire that is ſuſpended over the Earth, repreſents the boundary of light and darkneſs thereon, for that half of the Earth on that ſide of the wire which is next the Sun, is called, the enlightened Hemiſphere, and the half on the other ſide the darkened Hemiſphere.

9. The ſmall plain ivory ball, denotes the Moon, and is carried round the Earth in 29 ½ days, by means of the braſs arm, that communicates with the wheel work in the frame. For one revolution of the Earth round the Sun, this Moon goes 12 times and one third round the Earth, the ſame as the Moon in the Heavens. The Moon is fixed on a wire, which moves up and down in a ſocket at the arm before mentioned, ſo that the Moon may have her proper inclined motion in reſpect to the Earth's given her by the help of a

10. Flat braſs open rim, fixed under the Earth; moveable two ways, viz. either horizontally, or

vertically, ſo that when any inclination is given to this rim or orbit of the Moon, any poſition of this inclination may be given to it, and by that the exact inclined motion of the Moon in her orbit is repreſented, as alſo the Moon's Nodes, for that joint of the rim where it cauſes the Moon to begin to aſcend above the orbit of the Earth, is called the aſcending Node, and the oppoſite joint of the rim the deſcending Node: theſe two Nodes in the Heavens have a retrogade motion through the Signs of the Ecliptic in 19 years. The true poſition of them for any particular time may eaſily be found, as their places in the Ecliptic, are in all Ephemeris's, for the given year, and their places may be ſet in the Orrery accordingly, by means of another

11. Rim, fixed under the one above mentioned having all the Signs and Degrees of the Ecliptic inſerted on it, which Signs the learner ſhould know by heart, ſo as to call them by their names when ſeen. This Ecliptic circle alſo ſerves to ſhew the Moon's place in the Heavens, as ſeen from the Earth, and alſo the diſtance from the Sun that ſhe appears to have at any ſituation of her, in her orbit, for this Ecliptic as well as the orbit of the Moon, and the Earth, keeps its parallelism, or all the Signs and Degrees parallel to thoſe on the Board, in its revolution round the Sun, with the Earth.

12. Under the above two circles, is a Card, which is fixed to the frame of wheels by two ſcrews; this card has the age and phaſes of the Moon on it, with the initial letters N. M. 1 Qr. F. M. 3 Qr. ſignifying, that when the wire arm that carries round the Moon is over any of theſe letters, it is according to the letters the wire is

over, either New Moon, the firſt Quarter of the Moon; Full Moon, or the third or laſt Quarter of the Moon, alſo, when the above arm is over any Phaſe and Number, it ſhews the quantity of light on the Moon that appears to the Earth at the age there figured.

13. There is a ſmall tin lacquered lamp given with the Orrery, which is to be lighted with oil, and a very ſlender wick of cotton, then to be placed on the wire, that the braſs ball denoting the Sun, is ſcrewed to, which braſs ball muſt be unſcrewed, and the ſocket at the bottom of the lamp put on in the room of it; when the lamp is uſed the room where the Orrery is uſed ſhould be made quite dark. This lamp has an excellent effect in the uſe of the Orrery, for all the phænomena it is capable of repreſenting, are as it were realized by the light of this artificial Sun.

Having deſcribed the component parts of the Orrery, we now proceed to the uſe of it, wherein I ſhall give only a few examples, for there are a great many particulars to be ſhewn by it, which the learner will perceive as he encreaſes his knowledge in Aſtronomy, but could not be included in this ſmall tract.

14. The firſt thing neceſſary in the uſe of the Orrery is, to rectify it, which is done by the following means.

At the end of the frame neareſt the Sun, is a long braſs, wire ſerving as an Index to point out the ſeveral places of the Sun, as he appears to move by the Earth's annual motion, ſo that when this index points out the Sun in any particular ſign and degree, it is evident that the place of the Earth is in the oppoſite ſign and degree of the Ecliptic, as for example, lay hold of a round ſhoulder turned on the under ſide of the board with one of your hands, or place the board ſteady on a table, and then with the other hand turn the frame of wheels round, by a ſmall ivory handle fixed on the end of the frame fartheſt from the Sun, 'till the index points to the 21ſt of June, or to the firſt degree of Cancer, which indicates that at that time of the year, the Sun appears to be in the beginning of Cancer, and the Earth is in the beginning of the oppoſite ſign, viz. Capricorn, obſerving at the ſame time if the ſign of Cancer and Capricorn on the board are in a line with the ſigns Cancer and Capricorn on the ſmall Ecliptic under the Earth; if not, move the ſmall Ecliptic about 'till they are ſo; obſerve alſo that the inclination of the Earth's Axis is towards the ſign of Cancer, and if it is not, move its ſupporter round the ſteel wire until it is ſo; then turn the frame round, until the index points to the day of the month you would rectify it for, as ſuppoſe now, for June 1ſt, 1782, the index ſhews that the Sun is then in the 10th of Gemini, and conſequently the Earth in the 10th of Sagittarius, then looking in an Ephemeris or Almanack for the given year, for the place or age of the Moon, we find that the place of the Moon is in the 24th of Aquarius, and her age is 20 days, which place or age I ſet in the ſmall Ecliptic (ſee § 11) or the Card (ſee § 12). The place of the Moon's Aſcending Node I alſo find in the Ephemeris is in the 13th degree of Aries, I then bring the middle or axis of one of the joints of the flat rim (ſee § 10) over that degree and ſign, in the ſmall ecliptic, and elevate the rim in ſuch a manner that the half of it which is over Aries, Taurus, Gemini, &c. may be about a quarter of an inch higher than the other half eſtimating at thoſe parts of the rim that are fartheſt from the joints, taking care that while the Moon and this rim are ſetting, the Earth is kept in the poſition as before ſet, then is the Orrery rectified for any paſt or future time, and ready to be put in motion, firſt acquainting the learner that there is not to be expected any calculations from it, the ſmallneſs of the ſize not admitting it to be done with any accuracy, being only practicable on the large Orreries, Globes, &c.*

15. Still keeping the Earth in the above poſition, turn it round its Axis, with your finger, the ſame way as the order of the ſigns is, this Earth will then repreſent the daily motion of the real Earth, round the imaginary axis, (ſee § 10, Part I. and § 4, of this) in 24 hours. As you keep turning the Earth the braſs piece denoting London, will when in the middle of the enlightened half of the Earth, ſhew, that the Sun is then on the Meridian, or it is Noon; but as you keep turning the Earth London will be brought to the boundary wire, the Sun then to the Londoners is beginning to ſet, and when London is paſt the wire the Sun is quite ſet, it being to them evening and conſequently in darkneſs; when it is in the middle of the other Hemiſphere, it is to them midnight, but

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* As many gentlemen and ladies wou'd wiſh to be poſſeſſed of the large and complete Orreries, Planetariums, Cometariums, &c. as contrived by the late Meſſ. Ferguſon and Martin; this is to inform them, that they are accurately made and ſold at my Father's, as before directed.

arriving at the other ſide of the boundary wire, the Sun begins to riſe, and London then enters the enlightened hemiſphere, called Morning, and ſo on as before. The different lengths of days and nights will be explained in the following repreſentation of the four ſeaſons, Spring, Summer, Autumn, and Winter.

16. Now move the frame of wheels on, according to the order of the months or ſigns, until the index at the end of the frame points to the 20th of March, or the firſt degree of Aries, ſignifying that the Sun on the 20th of March, enters the ſign of Aries. Now looking at the Earth you will perceive that the Equator (ſee § 5, of this) is oppoſite to the center of the Sun, or that the Sun is over that part of the Ecliptic, which croſſes the Equator and aſcends to the Tropic of Cancer (§ 5 of this), and that the North Pole is exactly under the boundary wire; that the number of circles on each ſide of the wire is twelve, and by turning the Earth round its Axis we find that there is always that number, and as one half of the Earth is in the light, and the other half in darkneſs, conſequently on the 20th of March there is equal day and night all over the Earth; this is called the Vernal Equinox, and the ſeaſon of the year is Spring.

17. Moving the frame gently on, you will perceive the North Pole to come more and more into the light, and the quantity of hour circles or Meridians between the Equator and the North Pole, to encreaſe, and conſequently the length of days at that part of the Earth, thoſe having the longer days who live nearer the Pole. Turn the Earth round its Axis you will ſee that the ſituations London, at Sun riſing and at Sun ſetting, is at the diſtance nearly

of 16 hours ½, and at Sun ſetting to Sun-riſing about 7 ½, which is the length of day and night at this time of the year, at London, being the 21ſt of June, and as the Sun is over that part of the Ecliptic, which touches the tropic of Cancer, it is to the Northern Inhabitants the longeſt day and ſhorteſt Night, and the middle of that ſeaſon of the year called Summer.

18. Continuing to move the frame on, you will perceive part of the polar circle to retire under the boundary wire, until the 23d of September, or when by the index the Sun enters Libra. On that day the poſition of the Earth is every way the ſame as it was on the 20th of March (ſee § 16 of this) only at this time of the year it is called Autumn, or the Autumnal Equinox.

19. Proceed to move the frame on, in doing which the polar circle will be diminiſhing until the 21ſt of December, when the Sun enters Capricorn, and is over that part of the Ecliptic on the Earth, that touches the Tropic of Capricorn, when the North polar circle will be entirely in the dark hemiſphere, and the quantity of hour circles on the north ſide of the Equator leſs in the enlightened hemiſphere than in the dark hemiſphere. The poſition and affections of the Earth this day are in all reſpects the reverſe of thoſe on the 21ſt of June, and the time of the year is called Winter.

20. Turning the frame 'till the index points to the 20th of March, the year is then compleated, and the poſition of the Earth is the ſame as when you firſt began to move it.

21. While you are turning the frame onward, look at the North Pole and you will ſee that it is conſtantly in the light from the 20th of March to the 23d of September; and from the 23d of Sep-

tember to the 20th of March, conſtantly in the dark, which ſhews that there is but one day and night at each Pole, that they are of ſix months continuance, and when it is day at the North Pole, it is night at the South Pole, and vice verſa: alſo when it is Summer to the northern inhabitants, it is Winter to the ſouthern, and the contrary.

22. Continue to move the frame of wheels on the board, and you will perceive that while the index goes through a month, the Moon will have made juſt one revolution in her orbit, called a lunation, in the courſe of which lunation, when the Moon is between the Earth and the Sun, ſhe is called a New Moon, as is expreſſed by the card, (ſee § 12 of this) when moved a quarter round, in her firſt quarter, according to 1 Qr. on the card, when half round, a Full Moon, and when three quarters round, in her third quarter, and ſo on as before; but to repreſent her phaſes, as alſo the eclipſes more perfectly, we ſhall ſuppoſe the lamp to be lighted and placed on the center of the board, as before directed, (ſee § 13 of this) and as was alſo ſuppoſed to be done in the preceding account of the Seaſons, Day and Night, &c. then as you move the frame on, you will pleaſantly ſee all the phaſes that the Moon ſhews herſelf with, as ſeen from the Earth, as alſo her age at any ſituation of her in her Orbit, expreſſed by the aforementioned card; for when ſhe comes between the Earth and the Sun, or is new, her dark ſide will be towards the Earth, (ſhe having no other light but what ſhe receives from the Sun, and reflects to us,) conſequently ſhe will not then be viſible, unleſs ſhe eclipſes the Sun, which you will ſee by her ſhadow falling on the Earth, and the ſhadow will be high or low on the Earth, ac-

cording as the Moon is high or low in her Orbit. This Eclipſe is called an Eclipſe of the Sun, though properly it is an Eclipſe of the Earth, and all thoſe inhabitants that are, and will be, in the ſhadow, will ſee the Sun as eclipſed, and more or leſs ſo, as they are farther from, or nearer to the center of the ſhadow, from whence it is called either a Total or Partial Solar Eclipſe.

23. Turn the frame onward, 'till the Moon is in the oppoſite Part of her Orbit, or is Full (for Eclipſes never happen but when it is New or Full Moon, then you will perceive that all the Moon's enlightened Face is towards the Earth, except ſhe falls into the ſhadow of the Earth, which if ſhe does, there is then a Lunar Eclipſe, or an Eclipſe of the Moon, and will be viſible to all thoſe inhabitants, that are, and will, come into the darkened hemiſphere. The Eclipſes of the Moon are of a longer duration than the Eclipſes of the Sun, for the Earth having the greateſt ſhadow, the Moon will take more time to paſs through that ſhadow, than any part of the Earth will to paſs through that of the Moon.

24. Upon a ſight of theſe phænomena, one objection to the orrery may poſſibly ariſe, viz. in the orrery, Eclipſes happen at every New and Full Moon; but it is not ſo in the heavens, as they happen but very ſeldom: the reaſon of which may be very eaſily ſhewn by the orrery, by inclining the flat braſs rim, (ſee § 10 of this) as the diſtance of it from the ſmall ecliptic will admit, then by turning the frame on the board, you will perceive that Eclipſes will not happen at every New and Full Moon, but only when the Moon is in thoſe two parts of her Orbit called the Nodes, (ſee § 10, of this,) Thus is evidently pointed out to the

learner, the nature of that part of Aſtronomy ſo often talked of, and ſo little underſtood, but ſee this treated of at large in Ferguſon'sAſtronomy, and Martin's Young Gentleman and Ladies Philoſophy, before mentioned.

Thus much for this ſimple conſtructed Orrery, which the Tyro by now I dare ſay, underſtands the uſe of, but yet may complain that there is not all the Planets and Moons belonging to our ſyſtem repreſented in it, therefore is incomplete, in anſwer to which I preſume, that any perſon, once having a knowledge of the nature of the Earth's and Moon's motion round the Sun, can with very little fatigue to the mind, eaſily apprehend the nature of the motions of the reſt of the planets, their motions being the ſame way, and by the ſame cauſe, only at the diſtances ſpecified in part 1ſt. But for the ſake of thoſe perſons who would wiſh to have a complete ſet of the Planets, I have contrived a ſet of ſmall arms having all the Planets, to apply on the board occaſionally, in place of the Earth and Moon, alſo with a moveable Sun and Earth, ſo that the Ptolemaic and Copernican ſyſtem may be repreſented, and thereby ſhew the abſurdities that would ariſe if the Earth poſſeſſed the center of the ſyſtem, and the conſiſtency and agreement that there is in the preſent genuine and true Syſtem of the World, the Solar Syſtem.

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